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Carcass composition and breast muscle microstructure in selected *vs* non-selected ducks

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Forty ducks aged 7 weeks of strains A44 and P66 and conservative flocks P33 and K2 were investigated, 5 males and 5 females from each. Carcass composition was determined and microstructure of *pectoralis maior* muscle analysed.
Males and females of strain A44 and those from flock K2 were characterized by a significantly greater breast muscles per cent of carcass compared to strain P66 and flock P33, with a significantly lower per cent of thigh and of lower-thigh muscles in K2 males than in males P66 and P33. Carcasses of K2 females contained significantly less skin with subcutaneous fat (incl. neck skin) compared to A44, P66 and P33 females. *Pectoralis maior* muscle of males and females from both conservative flocks was characterized by significantly greater per cent of red fibres and lower per cent of white fibres, as well as smaller diameter of both fibre types. Moreover, the mean white fibre diameter in K2 was significantly lower than in P33 birds.
Satisfactory body weight found in birds of both sexes from conservative flock P33 , and considerable muscling, low fatness, greater per cent of red fibres and lower diameter of both fibre types in P33 and K2 birds indicate the feasibility of using them in production of valuable food and in breeding programmes aimed at improving the existing, and creating new, strain(s) of ducks.

KEY WORDS: ducks /carcass composition / muscle microstructure /selection

Breeding work carried out in Poland with five pedigree strains of Peking-type ducks [Książkiewicz 1995] has been aimed at increasing their muscling, particularly the breast muscles content of carcass, while decreasing carcass fatness. Moreover, conservative flocks of ducks are kept as a source of genes that are useful for breeders [Alderson 1990, Križ 1997, Książkiewicz 2002].

Selection of ducks for meat content of carcass may adversely affect the eating quality of meat, e.g. its tenderness [Powell 1992]. Meat tenderness is determined, among other factors, by per cent and diameter size of white and red muscle fibres. Varadarajulu and Cunningham [1971] and Kłosowska *et al*. [1994] reported that muscle fibre diameter is negatively correlated with meat tenderness. Thus, from the viewpoint of meat quality, a greater number of thinner fibres will be more favourable. However, different authors [Smith *et al.* 1993, Gille *et al.* 1998, Kłosowska *et al.* 1999 and Knust *et al.* 2000] have presented different results concerning per cent and diameter size of white and red muscle fibres of the breast muscle in ducks.

The aim of the present study was to compare ducks from two breeding strains and two conservative flocks for the carcass composition and the microstructure of *pectoralis maior* muscle.

Material and methods

Investigations were carried out with ducks of breeding strains A44 and P66, and conservative (preserve) flocks P33 and K2, aged 7 weeks, from the Department of Waterfowl Breeding (DWB), Dworzyska, National Research Institute of Animal Production.

Both breeding strains were created in the 1970s. Strain A44 was created with the use of Peking ducks that were bought from the Cherry Valley Farms, Great Britain, while P66 using old Polish strains of Peking ducks: P11, P22, P33, P44 and P55. In strain A44 selection was carried out mainly for meat content of carcass, while in strain P66 also reproductive traits were taken into account.

Both conservative flocks are included in the World Watch List for the Domestic Animal Diversity [2000]. Flock P33 has remained unselected since 1981. Flock K2 was created in 1978 at the DWB, Dworzyska, to obtain small-sized, but well muscled and leany birds [Książkiewicz 2002]. The foundation stock were wild mallards (*Anas platyrhynchos* L.) with predominantly white plumage, and British ducks characterized by low body weight. Within conservative flocks, only selection for conformation and health traits was performed with no reference to performance traits.

Birds were reared in groups of 100 (sex ratio 1:1) in a confined facility under controlled environment until 3 weeks of age, followed by restricted rearing on straw yards that were partly roofed. The feed mixture was offered *ad lib.* and contained 20% crude protein and 12.13 MJ metabolizable energy (ME) during first 3 weeks of age and 16.5% protein and 12.34 MJ ME from week 4 of age. Housing, feeding and grooming conformed with the current standards of duck rearing [Mazanowski *et al*. 1999, Książkiewicz 2002] and were identical for all birds. At the age of 7 weeks, all

the birds were individually weighed. From each group five males and five females were withdrawn with body weights similar to the mean for all males and females in group. The birds were slaughtered and their carcasses cooled at 4°C for 18 h. The carcass was divided into breast muscles, thigh and lower thigh muscles, skin with subcutaneous fat (incl. neck skin) and abdominal fat [Kisiel 2003], which were weighed. Then, per cent of carcass components (incl. neck) with neck was calculated for each animal.

Directly after exsanguination, samples of the *pectoralis maior* muscle were taken from the right side of breast near the keel (one sample per bird) and frozen in liquid nitrogen to obtain the cryostat slides 10 μm thick. To identify fibre types, reduced nicotinamide adenine dinucleotide tetrazolium reductase (NADH-TR) reaction was performed according to Dubowitz [1985]. Contents (%) of white (αW) and red fibres (αR + βR) were determined on each preparation (bird) based on analysis of 10 muscle bundles, *i.e*. about 900 muscle fibres, using the optical microscope (150×). The smallest diameters [Brooke 1970] of 200 fibres in each preparation (white and red pooled) were made with microscope image analysis system MultiScanBase v. 8.08. Then, mean diameter of white and red fibres was calculated for each bird.

Statistical evaluation was performed in two steps. First, some interaction effects were checked in preliminary analysis. Finally, the linear model (specific for each trait) was employed after Box-Cox transformation of the data. The body weight was included as covariance for muscle traits. The computations were performed by the SAS package programmes [SAS 1991].

Results and discussion

Males and females of A44 strain were characterized by a significantly higher body weight (by 225 g on average) than P66 males and females (Tab. 1). This is doubtless the result of long-term selection and can be related to the origin of birds. Similarly, within conservative flocks, P33 males and females appeared significantly heavier than males and females from K2 flock. This difference is explained by the fact that K2 was created with the use of birds of low body weight. Males from flock P33 were significantly heavier (by 220 g) than P66 males despite the fact that no selection for increased body weight had been carried out in conservative flocks. Body weights found in birds from two breeding strains and P33 conservative flock were similar to those of Peking-type ducks reported by Reiter *et al*. [1997] and Maruyama *et al.* [1999].

A44 males and females were characterized by significantly greater content of breast muscles (by about 2.5 per cent points – pp) compared to P66 birds. Significant differences appeared neither within males, nor within females of these strains in per cent of thigh and lower-thigh muscles of carcass. Within conservative flocks the carcasses of K2 females contained significantly more breast muscles (by about 1.6 pp) than did carcasses of P33 females, while P33 males had more (by about 1.4 pp) thigh and lower-thigh muscles of carcass than males K2. Birds of flock K2 (both sexes) showed significantly more breast muscles of carcass (by about 1.7 pp) than P66 (both sexes)

Table 1. Means and their standard deviations (SD) for bodyweight and carcass composition in ducks

Trait	Sex	Breeding strain				Conservative flock			
		A44		P66		P33		K2	
		mean	SD	mean	SD	mean	SD	mean	SD
Bodyweight (g)	males	3120^{a}	24.99	2830^{b}	24.99	3030^{a}	54.77	1810^{c}	48.99
	females	2870^{a}	24.99	2710^{b}	20.00	2670^{b}	24.49	1730^{c}	24.49
Content of carcass (%)									
breast muscles	males	14.2^{a}	0.93	11.9^{bc}	0.85	13.0^{b}	1.35	13.4^{ab}	1.74
	females	15.0^{a}	1.18	12.4^{b}	0.47	12.6^{b}	0.94	14.2^{ac}	1.84
thigh and lower-thigh muscles	males	12.8	0.92	13.5^{a}	0.44	13.3^{a}	0.88	11.9^{b}	1.25
	females	13.0	0.47	13.7	0.68	13.3	0.69	13.1	0.64
skin with subcutaneous fat (incl. neck skin)	males	30.2	1.64	29.4	1.93	29.8	1.65	31.0	2.34
	females	29.5^{a}	1.09	30.1^{a}	1.10	29.9^{a}	2.14	24.4^{b}	1.92
abdominal fat	males	2.2	0.38	2.2	0.30	2.3	0.50	2.4	0.66
	females	2.2	0.33	2.4	0.50	2.6	0.37	2.2	0.53

^{abc}In rows means bearing different superscripts differ significantly at $P \leq 0.05$.

birds. Birds from flock P33 were characterized by significantly lower per cent of breast muscles (by about 1.8 pp) compared to A44, with K2 males having significantly lower thigh and lower-thigh muscles content of carcass (by about 1.6 pp) than P66 males. Despite these differences, both muscle types contents of carcass in birds from breeding strains and conservative flocks appear similar to those reported for Peking ducks by Pingel *et al*. [1997].

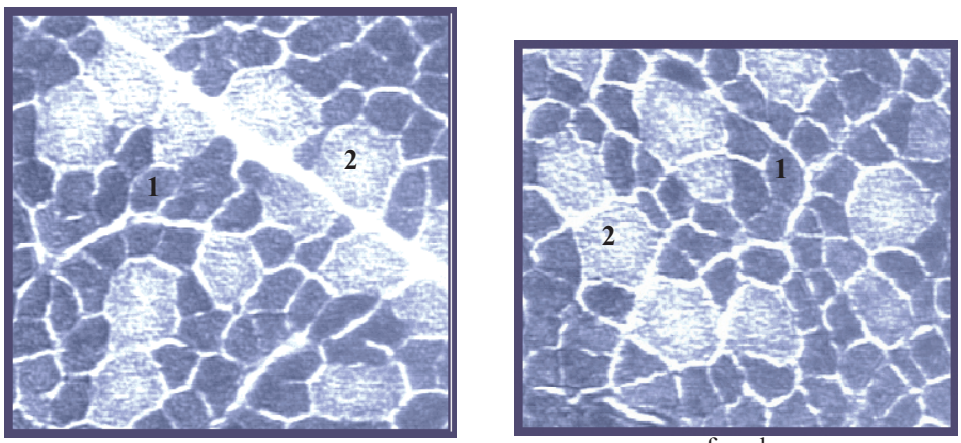
Significant differences were found neither within males, nor females between breeding strains for skin with subcutaneous fat (incl. neck fat) as well as abdominal fat content of carcass. A significant difference was found between conservative flocks within females, as carcasses of females from flock K2 were characterized by about 2.5 pp lower mean value of the trait of interest compared to those from flock P33. In addition, K2 males had significantly less (by about 2.7 pp) skin with subcutaneous fat (incl. neck skin) than males from both breeding strains. No significant difference was found between strains or flocks for the abdominal fat content of carcass. Mean values of the trait are similar to those reported for Peking ducks by Pingel *et al*. [1997, 1999].

Within breeding strains the *Pectoralis maior* muscles of A44 males and females contained significantly less (by about 5.9 pp) white fibres and more red fibres than those of males and females of P66 (Tab. 2, Fig. 1, 2). The content of both fibre types found in A44 birds was similar to that reported for 8-week-old ducks of the same strain by Kłosowska *et al*. [1999]. In turn, the muscle of males and females within conservative flocks (Tab. 2, Fig. 3, 4) was characterized by significantly lower (by about 2.9 pp)

Table 2. Means and their standard deviations (SD) for microstructure of breast muscle of ducks

Trait	Sex	Breeding strain				Conservative flock			
		A44		P66		P3		K2	
		mean	SD	mean	SD	mean	SD	mean	SD
Content of fibres (%)									
white	males	30.9^{a}	0.24	36.6^{b}	0.28	28.0^{c}	0.37	27.2^{c}	0.54
	females	29.4^{a}	0.08	35.4^{b}	0.37	27.2^{c}	0.50	26.8^{c}	0.60
red	males	69.1^{a}	0.24	63.3^{b}	0.28	72.0^{c}	0.37	72.8^{c}	0.54
	females	70.6^{a}	0.08	64.6^{b}	0.37	72.8^{c}	0.50	73.2^{c}	0.60
Fibre diameter (μm)									
white	males	33.1^{a}	3.30	36.4^{b}	3.28	29.2^{c}	0.64	25.0^{d}	0.32
	females	32.0^{a}	2.94	35.6^{b}	3.13	28.7^{c}	1.08	24.5^{d}	0.41
red	males	17.5^{a}	1.75	20.6^{b}	1.79	16.2^{c}	0.60	15.6^{c}	0.61
	females	16.9^{a}	1.73	20.0^{b}	2.06	15.8^{c}	0.72	15.1^{c}	0.58

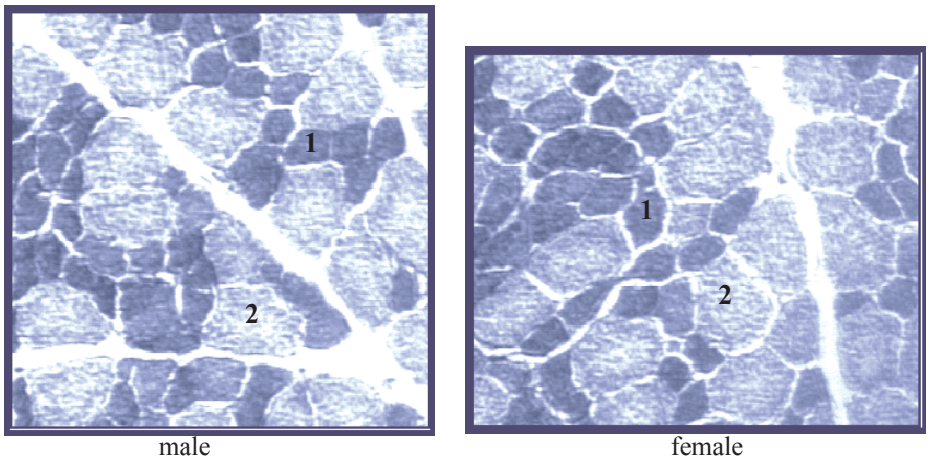
^{ab} In rows means bearing different superscripts differ significantly at $P \leq 0.05$.



male female

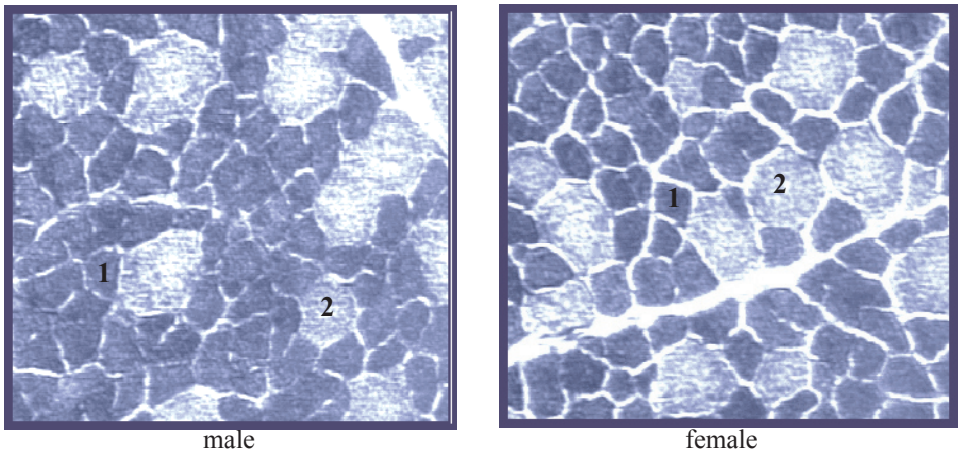
Fig. 1. Cross-section of breast muscle of male and female from strain A44. 1 – red fibre, 2 – white fibre.

content of white fibres and greater content of red fibres compared to the muscle of A44, and lower (by about 8.7 pp) compared to P66 birds muscle. The white fibres contents of breast muscles of birds from breeding strains and conservative flocks reported here appear considerably greater as compared to foreign data [Smith *et al.* 1993, Knust *et al.* 1995, 2000, Gille *et al*. 1998] who showed the *pectoralis maior* muscle of Peking ducks to contain 12.3-15.7% white fibres. Such a large difference is difficult to explain. It was



male female

Fig. 2. Cross-section of breast muscle of male and female from strain P66. 1 – red fibre, 2 – white fibre.



male female

Fig. 3. Cross-section of breast muscle of male and female from strain P33. 1 – red fibre, 2 – white fibre.

probably due to the different origin of the birds. The microstructure of *pectoralis maior* muscle in ducks can also be affected by the rearing system as shown by Tavanti *et al*. [1993] and Knust *et al*. [1995, 2000] who found more red fibres in muscles of the semi-intensively than in intensively reared ducks.

The breast muscle of A44 males as well as females was characterized by significantly lower (by about 3.3 μm) mean diameter of fibres of both types compared to P66 males and females, respectively (Tab. 2, Fig. 1, 2). The diameter of both types of fibres shown in the muscle of A44 birds in this study was similar to that found for birds of the same strain by Kłosowska *et al*. [1999]. The mean diameter of white fibres of P66

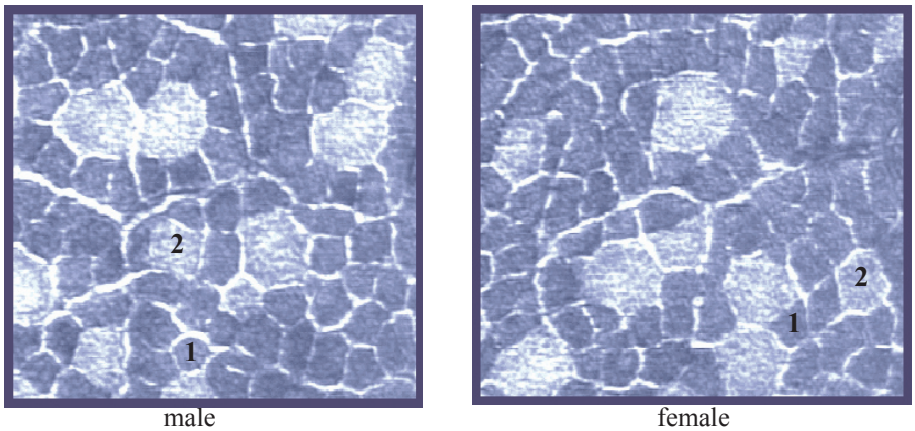


Fig. 4. Cross-section of breast muscle of male and female from strain K2. 1 – red fibre, 2 – white fibre.

birds appears similar to that reported for Peking ducks by Gille *et al*. [1998]. Breast muscle microstructure in birds from conservative flocks (Tab. 2, Fig. 3, 4) showed that K2 males and females both had a significantly lower (by 4.2 μm) diameter of white fibres. The mean diameters of white and red fibres found in breast muscle of P33 birds were similar to those reported for the same muscle in birds of the same flock by Kisiel [2003]. The diameter of white muscle fibres in birds of both conservative flocks was found significantly smaller than in A44 (by about 5.7 μm), and P66 (by about 9.1 μm) birds. Birds from the conservative flocks were also characterized by significantly smaller diameter of red fibres than A44 (by about 1.5 μm), and P66 (by about 4.6 μm) birds. The smaller diameters of fibres of both types found in birds from conservative flocks compared to breeding strains were similar to those shown by Kontecka *et al*. [2002] for breast muscle of 10- and 12-week-old Muscovy ducks, which are characterized by thin-fibre meat.

Satisfactory body weight found in birds from conservative flock P33 and considerable muscling and low fatness as well as greater per cent of red muscle fibres and lower diameters of both fibre types found in birds from both conservative flocks indicate the feasibility of using them in production of valuable food and in breeding programmes to improve the existing, and to create new, strain(s) of ducks.

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Podstawowe elementy tuszki i mikrostruktura mięśnia piersiowego kaczek selekcjonowanych i nieselekcjonowanych

S t r e s z c z e n i e

Materiał doświadczalny stanowiło 40 kaczek, po 5 samców i 5 samic, w wieku 7 tygodni z rodów hodowlanych A44 i P66 oraz stad zachowawczych P33 i K2. Przeprowadzono rozbiór tuszek i oceniono mikrostrukturę mięśnia piersiowego większego.

Tuszki samców i samic z rodu A44 oraz ze stada K2 zawierały (%) istotnie więcej mięśni piersiowych w porównaniu z tuszkami samców i samic rodu P66 i stada P33. W tuszkach samców ze stada K2 stwierdzono istotnie mniejszą zawartość (%) mięśni ud i podudzi niż w tuszkach samców z rodu P66 i ze stada P33. Tuszki samic K2 zawierały istotnie mniej skóry z tłuszczem podskórnym (wraz ze skórą z szyi) w porównaniu z tuszkami samic rodów A44 i P66 oraz stada P33. Mięsień piersiowy większy samców i samic ze stad zachowawczych charakteryzował się istotnie większą zawartością (%) czerwonych włókien mięśniowych, a mniejszą białych, a także mniejszą średnicą włókien obu typów. Średnice włókien białych osobników ze stada K2 były istotnie mniejsze niż osobników ze stada P33.

Zadawalająca masa ciała kaczek ze stada zachowawczego P33, a także znaczne umięśnienie i małe otłuszczenie oraz większa zawartość czerwonych włókien mięśniowych i mniejsze średnice obu typów włókien mięśniowych kaczek z obu stad zachowawczych, wskazują na możliwość wykorzystania tych ptaków w produkcji wartościowej żywności oraz w programach hodowlanych, które zmierzają do doskonalenia już istniejących, jak i do tworzenia nowych rodów kaczek.